Characterization of a Vibrating-Wire Viscosity Sensor for Corrosive Fluids

L. Aumann
Körting AG
Division S - Department STE
Badenstedter Strasse 56
30453 Hannover, Germany

A. Laesecke and R.A. Perkins
National Institute of Standards and Technology
Physical and Chemical Properties Division
Experimental Properties of Fluids Group
325 Broadway
Boulder, CO 80303 USA

T.O.D. Lüddecke
Universität Hannover
Institut für Thermodynamik
Callinstr. 36
30137 Hannover, Germany

The vibration of a stainless steel wire with a diameter of 152 μm was measured as a viscosity sensor for corrosive fluids at different excitation amplitudes. Conditions varied between vacuum, gaseous helium and nitrogen, liquid toluene and ethanol from 253 to 323 K with pressures up to 14 MPa. The wire exhibited nonlinear resonance behavior and hystereses with respect to frequency. An increase of its stiffness and a decrease of its internal damping occurred with increasing excitation. Mathematically, such "hysteresis damping" is described by a generalized Duffing-Van der Pol differential equation. The phenomenon occurs in all vibrating systems with elastic restoring forces but was not observed in vibrating-wire viscometers before, because thin tungsten wires were preferred due to their higher stiffness. If a different wire material is required for compatibility with a target fluid, the operating mode of the wire including its diameter has to be selected carefully. This may require measurement of the viscous damping on the wire in the free as well as in the forced mode of vibration. A sensitivity analysis revealed that the natural frequencies of the wire *in vacuo* and in fluids influence the calibration more strongly than the density and viscosity of the calibration fluid.